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CONFIRMATORY FACTOR ANALYSIS AND ESTIMATOR COMPARISON OF TWO SHORT FORMS OF AN IRRATIONAL AND RATIONAL BELIEFS SCALE

A thesis submitted in partial fulfillment
of the requirements for the degree of

MASTER OF ARTS

to the faculty of the

DEPARTMENT OF PSYCHOLOGY

of

ST. JOHN'S COLLEGE OF LIBERAL ARTS AND SCIENCES

at

ST. JOHN'S UNIVERSITY
New York
By
Joanne Raptis

Date Submitted _____________ Date Approved ___________

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ABSTRACT

CONFIRMATORY FACTOR ANALYSIS AND ESTIMATOR COMPARISON OF TWO SHORT FORMS OF AN IRRATIONAL AND RATIONAL BELIEFS SCALE

Joanne Raptis

The present study examined two abbreviated versions of the Attitudes and Beliefs Scale-2 (ABS-2) to compare their factor structure and ability to achieve model fit to the data. The original scale, a measure of irrational and rational beliefs as defined by REBT theory, was designed with 72 items reflecting irrational and rational beliefs and each involving one of four cognitive processes and one of three content areas. The ABS-2 had been criticized for its length and the inconsistency of findings regarding its factor structure. Two groups of researchers independently created short forms of the ABS-2 using 24 of the original items. One scale used the items with the highest factor loadings, while the other also prioritized maintaining balance across all dimensions. To also explore the effects of using different estimators, the authors ran Confirmatory Factor Analyses (CFAs) for each short form twice, once using the Maximum Likelihood Robust (MLR) estimator and once using Diagonally Weighted Least Squares (DWLS). The sample consisted of over 1500 participants that included university students, psychotherapy outpatients, and individuals in a drug rehabilitation program. Results showed that both scales yielded virtually equal and excellent fit indices when using the DWLS estimator but not when using MLR. The model with the best fit was an eight-factor bifactor model with factors for the irrational and rational cognitive processes and a general factor. Two other models also yielded especially excellent fit, including a two-factor bifactor model for irrationality and rationality as well as a second-order model with items loading on either one of the four irrational cognitive processes and then a second-order irrationality factor or on one of the four rational cognitive processes and a second-order rationality factor. Ultimately, the results suggest that the assessment can provide meaningful subscales for scores of the total, irrationality, rationality, cognitive processes, and content domains. Additionally, the findings highlight the importance of critically considering one's data and selecting an appropriate estimator as opposed to relying on default settings. Implications for the assessment of irrational and rational beliefs, furthering REBT research, and targeting treatment to client presentation across the three dimensions are discussed.

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INTRODUCTION

One of the first and most influential forms of cognitive-behavioral therapy is Rational Emotive Behavior Therapy (REBT), developed by Albert Ellis (1962). The theory at the foundation for this framework posits that irrational beliefs (IBs) underly psychological distress and that rational counterparts of these beliefs (RBs) can alleviate the disturbances they cause. Ellis (1994) hypothesized that all irrational beliefs involve one of four cognitive processes: demandingness (DEM), from which the other three stem, awfulizing (AWF), frustration intolerance (FI), and self-condemnation (SC). The rational counterparts of these beliefs include non-demanding preferences (NDP), realistic negative evaluations (RNE), frustration tolerance (FT), and self-acceptance (SA), respectively. The RBs are not necessarily positive or dismissive of the perceived problem, but instead are altered versions of the IBs that avoid cognitive distortions and extreme evaluations of those perceived ideas. Consequently, they are also associated with less psychological distress (Ellis, 1994).

Given that the theory of irrational and rational beliefs is central to REBT, it is essential that a scientifically validated measured of IBs and RBs exist for the therapy modality to both maintain its prominence in the field and also develop further. Numerous scales have been created to assess Ellis' IBs and RBs, but limitations to their designs have negatively impacted their validity, reliability, utility, and factor structure findings (David et al., 2019; Terjesen et al., 2009). One issue is that many scales measure both REBT's irrational beliefs as well as other CBT-based concepts (David et al., 2009). This design weakens the tests' ability to assess aspects of the theory such as how irrational beliefs are thought to lead to cognitive errors that then yield psychological distress. A second issue is that many items are written in a way that taps into psychological and behavioral functioning as opposed to purely assessing an individual's beliefs, and this can artificially inflate the correlation between one's beliefs and emotional functioning (David et al., 2019). A third issue is that most scales either measure irrational beliefs exclusively, ignoring their rational alternatives, or fail to have been updated to reflect Ellis' edited theory (David et al., 2019).

With these limitations in mind, DiGiuseppe, Leaf, Gorman, and Robin (2018) developed the Attitudes and Beliefs Scale-2 (ABS-2) to assess an individual's beliefs within the REBT framework. The scale includes 72 items that vary across three dimensions and that yield 24 three-item parcels. Firstly, the items are either irrationally or rationally worded. Secondly, the items represent either the rational or irrational versions of one of Ellis' four cognitive processes, namely DEM versus NDP, AWF versus RNE, FI versus FT, and SC versus SA. Thirdly, the items refer to situations involving either achievement, affiliation, or comfort-related content themes. The ABS-2 is therefore multifactorial and can generate several subscales across the different dimensions, such as a total scale score, total irrationality score, total rationality score, scores for the eight different cognitive processes, and scores for beliefs in the three content areas. Figure 1 displays the theoretical structure of the ABS-2. This range of scales can prove clinically useful, as one can assess an individual's level of irrationality as well as both the cognitive processes and life contexts most relevant to, or dysfunctional for, them. Critically, the ABS-2 circumvents the previously described limitations common to the other measures of REBT theory and has demonstrated good internal consistency (Cândea & Szentágotai-Tătar, 2014; DiGiuseppe et al., 2018; Macavei, 2005; Sava, 2009; Stefan & David, 2013; Szentagotai et al., 2008). Additionally, the measure has been shown to correlate with those of psychological disturbance and can also differentiate between clinical and nonclinical samples (Macavei, 2006; Macavei & Miclea, 2008; Moldovan & David, 2014; Opris & Macavei, 2007; Podina et al., 2015).

The ABS-2 suffers from two primary limitations. Firstly, the length of the scale presents a logistic challenge, as it requires a substantial amount of time from the individual completing the scale. Therefore, a short form would facilitate increased usage and further research for REBT. Secondly, and most critically, early research on the ABS-2 failed to support its theorized factor structure. A confirmatory factor analysis (CFA) conducted by Fülöp (2007) reportedly found adequate support for two models: a two-factor model with items loading on factors of irrationality and rationality and also a second-order model where the items loaded onto 24 first-order factors and then onto one of four second-order factors of irrationality, rationality, comfort, and self-condemnation. Unfortunately, the author did not provide the statistics on the models' degrees of fit, and the findings were also not replicated in a subsequent CFA by Hyland et al. (2014). Hyland's team instead found strongest support for an eight-factor model representing the four rational and four irrational cognitive processes and for a bifactor version of the same model with an additional set of factors that represented one of the three content domains of achievement, affiliation and comfort. The eight-factor bifactor model improved the fit indices. While this factor structure is indeed most consistent with REBT's theory of beliefs, the authors indicated that the fit indices did not reach levels considered adequate. Hyland and colleagues contended that, as CFAs typically load items on one factor to reach acceptable fit, the multifactorial nature of the ABS-2 presents a psychometric design flaw. Specifically, the authors argued that the content dimension of the items serves as a "nuisance" variable without theoretical backing that ultimately complicates attempts at factor analysis.

Based on the results of their CFA, Hyland et al. (2014) postulated that certain changes to the ABS-2 would improve the fit indices of its resulting factor structure. Specifically, they proposed that reducing the number of items to 24, without consideration for the content dimension nuisance variable, would reduce the error variance of the scale and also improve the feasibility of its usage. The items included in the resulting Attitudes and Beliefs Scale-Abbreviated Version (ABS-AV) were those with the highest factor loadings on the four irrational and four rational cognitive processes of each of the 24 three-items parcels. Consequently, the ABS-AV is imbalanced in its inclusion and distribution of content themes across its subscales. Hyland and colleagues (2014, 2016) then conducted two separate CFAs on the new abbreviated version of the scale. While the same eight-factor model again yielded the best fit, the indies still failed to reach levels considered adequate by accepted standards. The authors concluded again that the multifactorial structure of the ABS-2, specifically its inclusion of varying content areas, hinders the validity of its factor structure. In all instances of performing CFAs on the full-length ABS-2 and on the ABS-AV, they used the MLR estimator in their calculations.

Several subsequent studies suggested that the assertion by Hyland et al. (2014, 2016) characterizing the content dimension as a nuisance variable is inaccurate. Specifically, most resulting factors were represented powerfully by their content domains in exploratory factor analysis of the ABS-2 and in factor analyses of other REBT scales (DiGiuseppe et al., 2018; David et al., 2019). DiGiuseppe et al. (in press) performed a more recent CFA on the ABS-2, and their results ran counter, in many aspects, to those of Hyland and colleagues (2014, 2016). While DiGiuseppe et al. (in press) found the same eight-factor model of irrational and rational cognitive processes to best fit their data, models for each of the scale's three domains (irrationality vs. rationality, cognitive process, and content) also yielded excellent fit indices. Factors representing the three content domains had virtually equal support as those for the cognitive processes. This finding suggests that the content domain is not a nuisance variable but is instead a relevant and alternative way of characterizing beliefs.

Hyland and colleagues (2016) created their shortened version of the ABS-2 primarily to reduce error variance and improve model fit. They attempted this by selecting the three items for each of the eight cognitive processes that had the highest factor loadings on their respective factors. This rendered the content dimension unbalanced across the scale, and their scale failed to achieve adequate fit for any model tested. To address the concerns about the ABS-2's usability and factor structure from Hyland and others, the original authors of the ABS-2 created their own abbreviated version of the scale titled the DiGiuseppe, Robin, Leaf, & Gorman ABS-2 Short Form, or the DRLG short form (DiGiuseppe et al., 2020). Similar to the ABS-AV, the DRLG also has 24 items from the original scale, but these items were selected using different criteria. For each of the 24 parcels, one item out of three was selected based on three criteria. These included that the item correlated most highly with the total parcel score, best differentiated between clinical and nonclinical samples, and also correlated most highly with levels of disturbance. Consequently, the ABS-AV and DRLG both equally represent the eight total cognitive processes, but only the DRLG equally represents the three contents across scale's items. Balance in item content for the ABS-2 and its shortened versions could be critical in avoiding misinterpretations of data. For example, DiGiuseppe et al. (in press) noted that between-group variation in cognitive process scores on the ABS-AV may actually be explained by group differences in the relevance of content themes, which vary across subscales. Therefore, one aim of the present paper is to compare the factor structures of the two shortened forms and discuss the implications.

In sum, CFA studies on the factor structure of the ABS-2 and its abbreviated forms have yielded inconstant findings. The CFA by Fülöp (2007) tested several models but failed to obtain fit indices that reached accepted levels. Hyland et al. (2014) also performed a CFA on the full-length scale and found fit indices that fell short of the accepted standards in the field. Hyland et al. (2016) performed a CFA on their abbreviated version of the ABS-2, the ABS-AV, and again generated fit indices that did not reach standard levels of acceptability. However, DiGiuseppe et al. (in press) performed a CFA on the ABS-2 and did find excellent fit indices. Finally, DiGiuseppe, Raptis, Gorman, Agiurgioaei Boie, Agiurgioaei, Leaf, and Robin (2020) performed a CFA on a different abbreviated version of the ABS-2, the DRLG, and found several models with excellent fit. Hyland and colleagues (2014, 2016) always used the MLR estimator and DiGiuseppe and colleagues (in press, 2020) always used the DWLS estimator. This study examined whether differences in the statistical procedures used in these CFA studies accounted for the differences in the results.

As described above, it is noteworthy that CFAs for the same scale by different researchers yielded such varied results and conclusions. Fülöp (2007) reported closest fit for a two-factor model where items loaded on factors of irrationality and rationality and also for a second-order model where the items loaded onto 24 first-order factors and then onto one of four second-order factors of irrationality, rationality, comfort, and self-condemnation; Hyland et al.

(2014) found that an eight-factor model with factors representing the four rational and four irrational cognitive processes best fit the data, but the fit indices did not reach standards of acceptability; DiGiuseppe et al. (in press) found excellent fit for models representing each of the three ABS-2 domains and best fit for the same eight-factor model described by Hyland and colleagues (2014). It seems that the only differences among the methods of these previous studies were their sample compositions, sample sizes, and the estimation procedures used to run the CFA programs. Hyland and colleagues (2014, 2016) included samples of 313 and 397 university students, respectively, while DiGiuseppe et al. (in press, 2020) included college students, psychotherapy outpatients, and a drug rehab resident for a total sample of 1593. Additionally, Hyland's team used the Maximum Likelihood Robust (MLR) estimators, while DiGiuseppe and colleagues used the Diagonally Weighted Least Squares estimator.

Although the Maximum Likelihood (ML) and the MLR estimators are the most commonly used procedures in Structural Equation Modeling and CFA studies, some statisticians have argued against their use with categorical and ordinal data, such as the Likert format used in the ABS-2, or with samples involving multivariate non-normal distributions (Kaplan, 2009; Li, 2016; Lubke & Muthén, 2004). The ML and MLR estimators presuppose that a sample has met certain distributional assumptions. When using categorical data or ordinal from a sample that fails to meet these assumptions, the Diagonally Weighted Least Squares (DWLS: Mindrila, 2010) estimation is considered more appropriate. The DWLS was designed for this kind of data, makes no distributional assumptions, and is supported by several studies that have found it to generate less biased and more accurate estimations of factor loadings under these circumstances (Byrne, 2012; Flora & Curran, 2004; Li, 2016). Hyland and colleagues (2014, 2016) used MLR estimation in both of their studies that tested the factor structure of the full-length ABS-2 and the ABS-AV and were unable to find adequate fit for any model tested. However, DiGiuseppe et al. (in press) found an excellent fit for many models when using the DWLS estimator for the full-length ABS-2, and DiGiuseppe et al. (2020) found excellent fit for the abbreviated DRLG version. It is, therefore, possible that the discrepancy between the resulting factor structure findings of the ABS-2 and its short forms might have been a consequence of the different estimators used.

In summary, the aim of the present thesis is two-fold. Firstly, it is important to conduct and compare factor analyses of both the ABS-AV and DRLG short forms of the ABS-2 using the same sample in order to assess the impact of an imbalance in item content themes and to guide future usage of these scales. Secondly, it is critical to discover the extent to which estimators used in CFA analysis matter, as this can have substantial implications for past and current research in the field at large.

METHODS

Participants

Our total sample, which ultimately included 1,648 participants, was a conglomeration of data gathered from a wider range of sources and samples. Specifically, the sample included data from the original samples used by DiGiuseppe et al. (2018), the US college student group of the sample collected by Agiurgioaei-Boie et al. (2011), and a more recent sample of psychotherapy outpatients used by DiGiuseppe et al. (in press). Table 1 presents the demographic information for the different groups of participants used in the ultimate sample.

Measures:

The Attitude and Beliefs Scale – Abbreviated Version (ABS-AV). The ABS-AV is a measure of irrational and rational beliefs developed by Hyland et al. (2016). It is a shortened version of the ABS-2 by DiGiuseppe et al. (2018), and it contains 24 of the original scale's 72 items. There is equal representation of the four irrational and four rational cognitive processes in the number of items (i.e. DEM versus NDP, AWF versus RNE, FI versus FT, and SC versus SA), but the content themes among the items and subscales are not balanced. The items were selected based on which original ones were found to have the highest factor loadings by the short form's authors.

The DRLG-Short Form of the Attitudes and Belief Scale-2 (DRLG). The DRLG is a measure of irrational and rational beliefs developed by DiGiuseppe et al. (2020). It is a shortened version of the ABS-2 by DiGiuseppe et al. (2018), and it contains 24 of the original scale's 72 items. There is an equal representation of the four irrational and four rational cognitive processes in the number of items (i.e. DEM versus NDP, AWF versus RNE, FI versus FT, and SC versus SA), and the content themes among the items and scales are also balanced. The items were selected based on which of the original items in each of the 24 3-item parcels correlated highest with its parcel's total, distinguished best between clinical and nonclinical individuals, and correlated most highly with measures of disturbance.

Procedure:

All participants were given the full ABS-2 to complete. Individuals in the various clinical outpatient samples completed the full scale at their first intake appointment as part of a battery of demographic and psychological questionnaires. The different student groups in the sample all completed the scale independently and outside of class meeting times. Individuals in the substance abuse rehab facility completed the scale before program admission.

As less than one percent of the total data was missing, mean substitution was used to replace the missing values with the item's mean value from the participant's sample group.

Analysis Plan:

Confirmatory Factor Analysis (CFA). The author conducted CFAs on a number of models representing the factor structure for both the ABS-AV and the DRLG, testing the same models and using the same sample for each of the two scales. The analyses were run using the JASP open-source statistics program (Goss-Sampson, 2019; JASP, 2018) and the Structural Equation Modeling program from The *lavaan* Project (Rosseel, 2012). Table 2 includes descriptions of the seven models tested.

As expanded upon above, the Maximum Likelihood (ML) and the Maximum Likelihood Robust (MLR) estimators are most commonly used in CFAs, but many statisticians have argued against their use with categorical data involving multivariate non-normal distributions, such as the Likert format data gathered using the ABS-2 (Kaplan, 2009; Li, 2016; Lubke & Muthén, 2004). Instead, Diagonally Weighted Least Squares (DWLS: Mindrila, 2010) is an estimation procedure designed specifically to correct for multivariate non-normal data. To ascertain whether the estimator used can account for such marked differences in results and conclusions across analyses (see Hyland et al., 2016; DiGiuseppe et al., in press), the same CFAs and models were run twice for each short form, once using MLR and once using DWLS.

Fit Indices. To assess and evaluate the relative fits of the various models, the author presented a number of fit indices provided by the CFA program for each analysis. While they share certain statistical outputs, MLR provides the commonly reported Akaike Information Criteria (AIC) and Bayesian Information Criteria (BIC) while DWLS does not. As an alternative method of evaluation, the χ^2/df index, Expected Cross-Validation Index (ECVI: Schermelleh-Engel et al., 2003), and some other indicators were reported for each analysis. Loehlin (2004) proposed that a χ^2/df index value lower than 2 indicates that the model is over-fit, that 2 is ideal, and that values above 2 indicate good fit. The ECVI is used when calculating the AIC and correlates well with its ranking of model fit, and a comparatively lower ECVI value is thought to indicate better model fit. (Schermelleh-Engel et al., 2003). In addition, the following indicators were also reported: for χ^2 value, the degrees of freedom, the Root Mean Square Error of Approximation (RMSEA), the Standardized Root Mean Square Residual (SRMR), the Bentler-Bonett Normed Fit Index (NFI), the Cumulative Fit Index (CFI), the Tucker-Lewis Index (TLI), Bollen's Relative Fit Index (RFI), and Bollen's Incremental Fit Index (IFI). Hooper et al. (2008) have published suggested standards for assessing the acceptability of fit based on these indicators, specifically indicating that values of 0.06 or lower on the RMSEA, 0.08 or lower on the SRMR, and 0.95 or higher for the other indices are desired.

RESULTS

Table 3 presents the results of the CFA for the ABS-AV using the MLR estimator, and Table 4 presents the CFA results for the ABS-AV using the DWLS estimator. Table 5 presents the results of the CFA for the DRLG using the MLR estimator, and Table 6 presents the CFA results for the scale using the DWLS estimator. All tables provide fit indices statistics for the Chi-Square Test, degrees of freedom, number of parameter, ratio of χ^2 to degrees of freedom (χ^2/df), Expected Cross-Validation Index (ECVI), Root Mean Square Error of Approximation (RMSEA), Standardized Root Mean Square Residual (SRMR), Bentler-Bonett Normed Fit Index (NFI), Comparative Fit Index (CFI), Tucker-Lewis Fit Index (TLI), Bollen's Relative Fit Index (RFI), and Bollen's Incremental Fit Index (IFI). The tables for the CFAs run using the MLR estimator also report the Akaike Information Criteria (AIC) and Bayesian Information Criteria (BIC) indices.

CFAs for the ABS-AV using MLR and DWLS:

As presented in Table 3 for the analysis using the MLR, Model 5G, the bifactor model where all items load onto one of four irrational cognitive process factors or one of the four rational cognitive process factors and then also load onto one general factor, displayed the best fit overall when compared to the other models tested. The χ^2/df of all models presented were above 3, but that of Model 5G was closest to the ideal value of 2. Additionally, this model generated the lowest ECVI score of those tested and also met the criteria for acceptable fit based on the RMSEA and SRMR indices. However, the various fit indices for the NFI, CFI, TLI, RFI and IFI ranged from 0.93 to 0.96, and therefore they did not all reach the acceptable cutoff of 0.95 or higher.

Table 4 provides the fit indices for the CFA of the ABS-AV using the DWLS estimator, and overall the results were superior to those using the MLR estimator and indicated an excellent fit for many of the models. Again, Model 5G yielded the best fit, but as opposed to when using the MLR estimation, it now met the standards of all criteria of acceptability for all examined fit indices. Ultimately the best fit for the ABS-AV factor structure was achieved by Model 5G when using the DWLS estimation procedure. Thus for the ABS-AV items, the MLR and DWLS both found the same model to have the best fit, but the DWLs yielded higher fit indices and found stronger support for the models.

CFAs for the DRLG using MLR and DWLS:

Table 5 presents the results of the CFA for the DRLG using the MLR estimator. As was the case for the ABS-AV, again Model 5G had the best fit overall when compared to the other models tested. The χ^2/df of all models presented were above 3, but that of Model 5G was closest to the ideal value of 2 (although much higher). Additionally, this model generated the lowest ECVI score of those tested and also met criteria for acceptable fit based on the RMSEA and SRMR indices. However, while its CFI and IFI values were 0.95 or higher, unlike those of all of the other models, this standard was not met for the NFI, TLI, or RFI.

Table 6 provides the fit indices for the CFA of the DRLG using the DWLS estimator, and overall the results were superior to those using the MLR estimator for all models and indicated excellent fit for many of them. Again, Model 5G yielded the best fit, but as opposed to when using MLR estimation, it now met the standards of all criteria examined. Ultimately, and as in the case of the ABS-AV, the best fit for the DRLG factor structure was provided by Model 5G when using the DWLS estimation procedure. Thus, for the DRLG items, the MLR and DWLS both found the same model to have the best fit, but the DWLS yielded higher fit indices and found stronger support for the models.

DISCUSSION

The Attitudes and Beliefs Scale-2 was developed as an assessment of beliefs based on the theoretical model from REBT (DiGiuseppe et al., 2018; Ellis, 1994). The scale includes 72 items that vary along three different dimensions in an equal distribution. These include being either rationally or irrationally worded, involving one of four irrational or four rational cognitive processes, and involving one of three content themes. However, the scale suffers from its length, which renders it cumbersome to complete and distribute widely, and from disagreement in the field on the strength of the support for its factor structure (Fülöp, 2007; Hyland et al., 2014, 2016; DiGiuseppe et al., 2018). Two short forms, the ABS-AV and the DRLG (Hyland et al., 2016; DiGiuseppe et al., 2020**),** were independently created later from the original scale to increase its usability. Ultimately the present paper presents four CFA analyses and examines differences between both the factor structure results of the two short forms and also whether the use of specific estimators significantly impacts results, possibly explaining the large discrepancies between past analyses of the ABS-2 factor structure by different researchers.

As with the ABS-2 CFA (DiGiuseppe et al., in press), the results of the present study indicate that the best fitting model for both short forms was achieved through Model 5G, a bifactor model with factors for the eight total irrational and rational cognitive processes and a general factor onto which all items load, when using the DWLS estimator for the CFA procedure. This suggests that the two short forms can provide valid subscales for each of the eight cognitive processes, an irrationality, rationality, and a total score. Importantly, Model 2G, a bifactor model with factors for irrationality, rationality, and a general factor, was the second-best fitting model. Additionally, Model 7, a second-order model with items loading on either one of the four irrational cognitive processes and then a second-order irrationality factor or on one of the four rational cognitive processes and then a second-order rationality factor, also yielded excellent fit indices. The support for Model 2G and Model 7 by the data supplements the justification for examining the two short forms through separate subscales of total irrationality, total rationality, and an overall total score.

While both short forms include 24 items, the ABS-AV and the DRLG differ greatly in which items from the original scale they include and in how those items were chosen. Both tests equally represent irrationality, rationality, and the eight cognitive processes across their items. However, the DRLG is balanced across all three dimensions while the ABS-AV is not balanced in terms of its items' content. The authors of the latter claimed that content is a nuisance variable that interferes with attempts at analyzing the factor structure (Hyland et al., 2014). When comparing the two short forms themselves, ultimately both the ABS-AV and the DRLG achieved comparatively excellent fit. As is evident from the χ^2/df and the ECVI values in Tables 4 and 6, the fit indices were better for all models using the DRLG except for models 4, 4G, and 5G. As the ABS-AV was created using items with the highest factor loadings on the cognitive processes, it follows soundly that the models specifically based on the cognitive processes would fit this scale especially well. However, the fit statistics for those models were also excellent for the DRLG, and thus using the ABS-AV does not appear to provide a meaningful advantage. However, any comparison of the two sets of fit indices should be done cautiously, as that the two short forms include different items in their overlapping subscales.

The models representing each of the three domains independently also demonstrated excellent fit, including the model with factors representing each of the three content areas. This factor structure support serves as an additional counter to Hyland et al.'s argument that the content domain is a nuisance variable (2014). Ultimately, the present results appear to justify separate subscales for the eight cognitive processes, three content domains, irrationality, rationality, and the total score. This ultimately widens the clinical utility of the original and short forms of the ABS-2, as it expands the clinical issues that the administrator can explore and measure. As excellent support was found for both the ABS-AV and the DRLG's factor structure, the advantage of one short form over the other will be external to matters of fit. The balance of the content domain in the DRLG yields a broader range of issues and themes with which participants to more readily identify. Additionally, the equal representation of content themes across cognitive processes in the DRLG circumvents the possibility of conflating between-group differences in subscale scores as being due to differences in cognitive processes when actually caused by differences in content relevance, and vice-versa. This echoes the advice of statisticians that models be theoretically sound in addition to satisfying numerical standards of fit (Byrne, 2012). Therefore, it appears that the DRLG is generally preferable for use over the ABS-AV.

Arguably one of the most clear and impactful contributions of the data is the finding that the estimator used for CFA significantly influences the resulting factor structure outputs when using Likert format scale items or ordinal data. Past studies have failed to consistently find support for the factor structure of the ABS-2 or its short forms (Fülöp, 2007; Hyland et al., 2014, 2016; DiGiuseppe et al., 2018). The present study found excellent fit indices supporting the factor structure for both short forms when using the DWLS estimator but not when using the standard MLR estimator. This provides a potential explanation for the varied results and conclusions among researchers studying the ABS-2 factor structure. Furthermore, this also has significant implications for researchers in the field at large, as many psychological studies involve multivariate non-normal data and Likert scales. The recommendation that follows from the present paper is not to only use the DWLS estimator for similar types of data, as others have found support for this scale's factor structure using other methods of CFA (Artiran & DiGiuseppe, 2020). Instead, it seems essential that researchers critically consider the nature of their data and the default settings of their analyses before performing the statistical tests. Relying on commonly used defaults of functions, such as MLR estimator, may ultimately conceal important results and sway the conclusions that follow if the setting is inappropriate to the data.

Limitations and future research

There are several limitations to the present study, and many of these issues provide clear directions and inquiries for future research. Firstly, data for analyses of the ABS-AV and DRLG were obtained from administrations of the original ABS-2. It is possible that a participant's score when taking the short forms themselves would differ from their score on the short form items taken from the original scale due to potential effects of differences in test length, surrounding test items, and order of item appearance on participant responses. Therefore, future research should attempt to replicate these findings and conduct further studies using administrations of the short forms themselves. Secondly, it is important to note that the comparison of the fit indices of the two abbreviated scale is limited, as the scales contain different items in their overlapping subscales. Therefore, any conclusions drawn about the superiority of either should be done cautiously. Thirdly, the present paper presents evidence for the importance of the estimator used in CFA, and further studies examining this comparison on CFAs of other scales are recommended in order to strengthen the generalizability of the findings. Lastly, it is essential to differentiate between the concepts of best fit and of validity. While using the DWLS estimator helped the model and data fit together better and to reach superior fit indices when compared with using MLR, this does not mean that the fit indices provided by using the former are necessarily more correct. Future research should also include the use of Monte Carlo studies to determine whether the better fit is indeed more accurate as well in this case (Bandalos & Leite, 2006).

The implications of the present findings for future clinical study and scientific progress are significant. Firstly, the support for the abbreviated versions of the ABS-2 will allow for much broader, more feasible, and more frequent, assessment of individuals' irrational beliefs, rational beliefs, cognitive processes, and content areas of relevance. This will facilitate increased use of these measures for both clinical and research purposes. Future researchers may want to investigate whether particular CBT techniques target specific beliefs or behaviors differently. For example, one intervention may lead to a decrease in scores of demandingness or of total irrationality over time. If the effects of different approaches can be mapped out, it is imaginable that clinicians may be able to assess an individual's score in the different domains at baseline and then craft an informed treatment program based on what areas score as more relevant or dysfunctional for them

APPENDIX

Table 1: Demographic information for the groups comprising the ultimate sample

Sample Source	Description	Location	Sample Size	Gender (M:F)	Age Range (Mean, SD)	Race (%)
DiGiuseppe et al. (2018)	Clinical Outpatients	U.S. (NYC)	356	42:58	19- 75 years (36.4; SD= 9.4)	87: Caucasian 6: African American 5: Hispanic 2: Asian American
	Undergrad & Graduate Students	U.S. (NYC)	722	Not available	18- 23 years (20.7; SD= 3.08)	76: Caucasian 14: African American 10: Asian American 6: Hispanic
	Substance Abuse Rehab Residents	U.S.	67	56:44	20- 49 years (29.6; SD=8.4)	66: Caucasian 24: African American 10: Hispanic
Agiurgioaei-Boie et al. (2011)	Undergrad & Grad Students	U.S. (NYC)	163	Not available	18- 25 years (21.2; SD= 2.6)	Not available
Albert Ellis Institute (Collected from 2014-2019)	Clinical Outpatients	U.S. (NYC)	340	40:60	(38.5; SD= 10.11)	Not available

Table 2: Descriptions of the models run using CFA

Models run using confirmatory factor analysis to examine the factor structures of both the ABS-AV and the DRLG.

Models	Description
Model 1:	One-factor: All items load on one factor.
Model 2:	Two-factor: All irrational items load onto an irrationality factor and all rational items load onto a rationality factor.
Model 3:	Three-factor: All items load onto one of three factors representing the three content themes of achievement, affiliation, and comfort.
Model 4:	Four-factor: All items load onto one of four cognitive process factors without differentiation between rationality and irrationality.
Model 5:	Eight-factor: All items load onto one of eight factors, which include factors representing the four irrational and four rational cognitive processes (i.e. demandingness vs non-demanding preference, awfulizing vs realistic negative evaluation, frustration intolerance vs frustration tolerance, and self-condemnation vs self-acceptance).
Bifactor Models	
Model 2G:	Bifactor two-factor: All items load onto either an irrationality or rationality factor, and then all items load onto one general factor.
Model 3G:	Bifactor three-factor: All items load onto one of three content factors, and then all items load onto one general factor.
Model 4G:	Bifactor four-factor: All items load onto one of four cognitive process factors collapsed across the irrationality/ rationality dimension and then all load onto one general factor.
Model 5G:	Bifactor eight-factor: All items load onto one four irrational or four rational cognitive process factors and then all load onto one general factor.
Higher-Order Models	
Model 6	Second-order eight-factor: All items load onto one four irrational or four rational cognitive process factors and then all load onto one second-order general factor.
Model 7:	Second-order eight-factor: All items load onto either one four irrational cognitive process factors, which then load onto a second-order irrationality factor, or onto one of four rational cognitive process factors, which then load onto a second-order rationality factor.

<u>Table 3: Results of the CFA for the ABS-AV using lavaan and MLR estimation</u>

Results of the CFA for the **ABS-AV**. All models tested using lavaan with Maximum Likelihood Robust estimation.

Reporting Chi-Square Test of Model Fit, Degrees of Freedom, Ratio of χ^2 to degrees of freedom (χ^2 /*df*), Expected Cross-Validation Index (ECVI), Root Mean Square Error of Approximation (RMSEA), Standardized Root Mean Square Residual (SRMR), Bentler-Bonett Normed Fit Index (NFI), Comparative Fit Index (CFI), Tucker-Lewis Fit Index (TLI), Bollen's Relative Fit Index (RFI), and Bollen's Incremental Fit Index (IFI).

Models	χ^2	*df*	*# of param-eters*	χ^2/df	AIC	BIC	ECVI	RMSEA	SRMR	NFI	CFI	TLI	RFI	IFI
Model 1	5554.92	252	72	22.04	149665.85	150072.49	2.72	0.10	0.08	0.68	0.69	0.66	0.65	0.69
Model 2	4917.61	251	73	19.59	149030.54	149442.83	2.42	0.09	0.07	0.72	0.73	0.70	0.69	0.73
Model 3	4572.42	249	75	18.36	148689.35	149112.93	2.25	0.09	0.08	0.74	0.75	0.72	0.71	0.75
Model 4	3184.23	246	78	12.94	147307.16	147747.68	1.59	0.08	0.06	0.82	0.83	0.81	0.80	0.83
Model 5	1425.40	224	100	6.36	145592.33	146157.11	0.78	0.05	0.04	0.92	0.93	0.91	0.90	0.93
Bifactor Models														
Model 2G	1835.67	225	99	8.16	146000.60	146559.73	0.97	0.06	0.04	0.90	0.91	0.89	0.87	0.91
Model 3G	2645.33	222	102	11.92	146816.25	147392.33	1.36	0.07	0.05	0.85	0.86	0.83	0.81	0.86
Model 4G	1564.55	218	106	7.18	145743.47	146342.14	0.85	0.05	0.04	0.91	0.92	0.90	0.89	0.92
Model 5G	879.12	192	132	4.58	145110.05	145855.56	0.55	0.04	0.03	0.95	0.96	0.94	0.93	0.96
Higher-Order Models														
Model 6	2467.97	244	80	10.11	146594.90	147046.72	1.25	0.07	0.06	0.86	0.87	0.85	0.84	0.87
Model 7	2302.13	243	81	9.47	146431.06	146888.53	1.18	0.06	0.06	0.87	0.88	0.87	0.85	0.88

Note: X^2= Chi-Square Test of Model Fit; ECVI= Expected Cross-Validation Index; RMSEA = Root Mean Square Error of Approximation; CFI = Cumulative Fit Index; TLI = Tucker- Lewis Index; SRMR = Standardized Root Mean Square Residual; Bentler-Bonett Normed Fit Index (NFI); Bollen's Relative Fit Index (RFI); Bollen's Incremental Fit Index (IFI)
N = 1593.

Table 4: Results of the CFA for the ABS-AV using lavaan and DWLS estimation

Results of the CFA for the **ABS-AV.** All models tested using lavaan with Diagonally Weighted Least Squares estimation.
Reporting Chi-Square Test of Model Fit, Degrees of Freedom, Ratio of χ^2 to degrees of freedom (χ^2 /df), Expected Cross-Validation Index (ECVI), Root Mean Square Error of Approximation (RMSEA), Standardized Root Mean Square Residual (SRMR), Bentler-Bonett Normed Fit Index (NFI), Comparative Fit Index (CFI), Tucker-Lewis Fit Index (TLI), Bollen's Relative Fit Index (RFI), and Bollen's Incremental Fit Index (IFI).

Models	χ^2	*df*	*# of parameters*	χ^2/df	**ECVI**	**RMSEA**	**SRMR**	**NFI**	**CFI**	**TLI**	**RFI**	**IFI**
Model 1	3444.91	252	48	13.67	1.69	0.08	0.08	0.91	0.92	0.91	0.91	0.92
Model 2	2946.31	251	49	11.74	1.45	0.07	0.08	0.93	0.93	0.93	0.92	0.93
Model 3	2923.93	249	51	11.74	1.44	0.07	0.08	0.93	0.93	0.93	0.92	0.93
Model 4	1831.02	246	54	7.44	0.93	0.06	0.06	0.95	0.96	0.96	0.95	0.96
Model 5	796.54	224	76	3.56	0.45	0.04	0.04	0.98	0.99	0.98	0.98	0.99
Bifactor Models												
Model 2G	817.29	225	75	3.63	0.46	0.04	0.04	0.98	0.99	0.98	0.98	0.99
Model 3G	1361.44	222	78	6.13	0.72	0.05	0.05	0.97	0.97	0.96	0.96	0.97
Model 4G	734.57	218	82	3.37	0.43	0.03	0.04	0.98	0.99	0.98	0.98	0.99
Model 5G	428.46	192	108	2.23	0.31	0.02	0.03	0.99	0.99	0.99	0.99	0.99
Higher-Order Models												
Model 6	1956.34	244	56	8.02	0.99	0.06	0.06	0.95	0.96	0.95	0.95	0.96
Model 7	1763.60	243	57	7.26	0.90	0.06	0.06	0.96	0.96	0.96	0.95	0.96

Note: X^2= Chi-Square Test of Model Fit; ECVI= Expected Cross-Validation Index; RMSEA = Root Mean Square Error of Approximation; CFI = Cumulative Fit Index; TLI = Tucker- Lewis Index; SRMR = Standardized Root Mean Square Residual; Bentler-Bonett Normed Fit Index (NFI); Bollen's Relative Fit Index (RFI); Bollen's Incremental Fit Index (IFI)
N = 1593.

Table 5: Results of the CFA for the DRLG using lavaan and MLR estimation

Results of the CFA for the **DRLG.** All models tested using lavaan with Maximum Likelihood Robust estimation.

Reporting Chi-Square Test of Model Fit, Degrees of Freedom, Ratio of χ^2 to degrees of freedom (χ^2/df), Expected Cross-Validation Index (ECVI), Root Mean Square Error of Approximation (RMSEA), Standardized Root Mean Square Residual (SRMR), Bentler-Bonett Normed Fit Index (NFI), Comparative Fit Index (CFI), Tucker-Lewis Fit Index (TLI), Bollen's Relative Fit Index (RFI), and Bollen's Incremental Fit Index (IFI).

Models	χ^2	*df*	*# of parameters*	χ^2/df	AIC	BIC	ECVI	RMSEA	SRMR	NFI	CFI	TLI	RFI	IFI
Model 1	3392.10	252	72	13.46	146919.39	147326.03	1.69	0.08	0.05	0.82	0.83	0.81	0.80	0.83
Model 2	2603.30	251	73	10.37	146132.58	146544.87	1.31	0.07	0.05	0.86	0.87	0.86	0.85	0.87
Model 3	2959.33	249	75	11.88	146492.61	146916.19	1.48	0.07	0.05	0.84	0.85	0.84	0.83	0.85
Model 4	2959.98	246	78	12.03	146499.26	146939.79	1.49	0.07	0.05	0.84	0.85	0.84	0.82	0.85
Model 5	1833.76	224	100	8.19	145417.04	145981.82	0.97	0.06	0.04	0.90	0.91	0.89	0.88	0.91
Bifactor Models														
Model 2G	1707.54	225	99	7.59	145289.04	145848.17	0.91	0.06	0.04	0.91	0.92	0.90	0.89	0.92
Model 3G	1545.99	222	102	6.96	145133.27	145709.35	0.84	0.05	0.04	0.92	0.93	0.91	0.90	0.93
Model 4G	1854.96	218	106	8.51	145450.24	146048.91	0.99	0.06	0.04	0.90	0.91	0.89	0.88	0.91
Model 5G	1173.87	192	132	6.11	144821.15	145566.66	0.69	0.05	0.03	0.94	0.95	0.92	0.91	0.95
Higher-Order Models														
Model 6	2930.07	244	80	12.01	146473.35	146925.17	1.47	0.07	0.05	0.84	0.85	0.84	0.82	0.86
Model 7	2309.03	243	81	9.50	145854.31	146311.78	1.18	0.06	0.05	0.88	0.89	0.87	0.86	0.89

Note: X^2= Chi-Square Test of Model Fit; ECVI= Expected Cross-Validation Index; RMSEA = Root Mean Square Error of Approximation; CFI = Cumulative Fit Index; TLI = Tucker- Lewis Index; SRMR = Standardized Root Mean Square Residual; Bentler-Bonett Normed Fit Index (NFI); Bollen's Relative Fit Index (RFI); Bollen's Incremental Fit Index (IFI)

N = 1593.

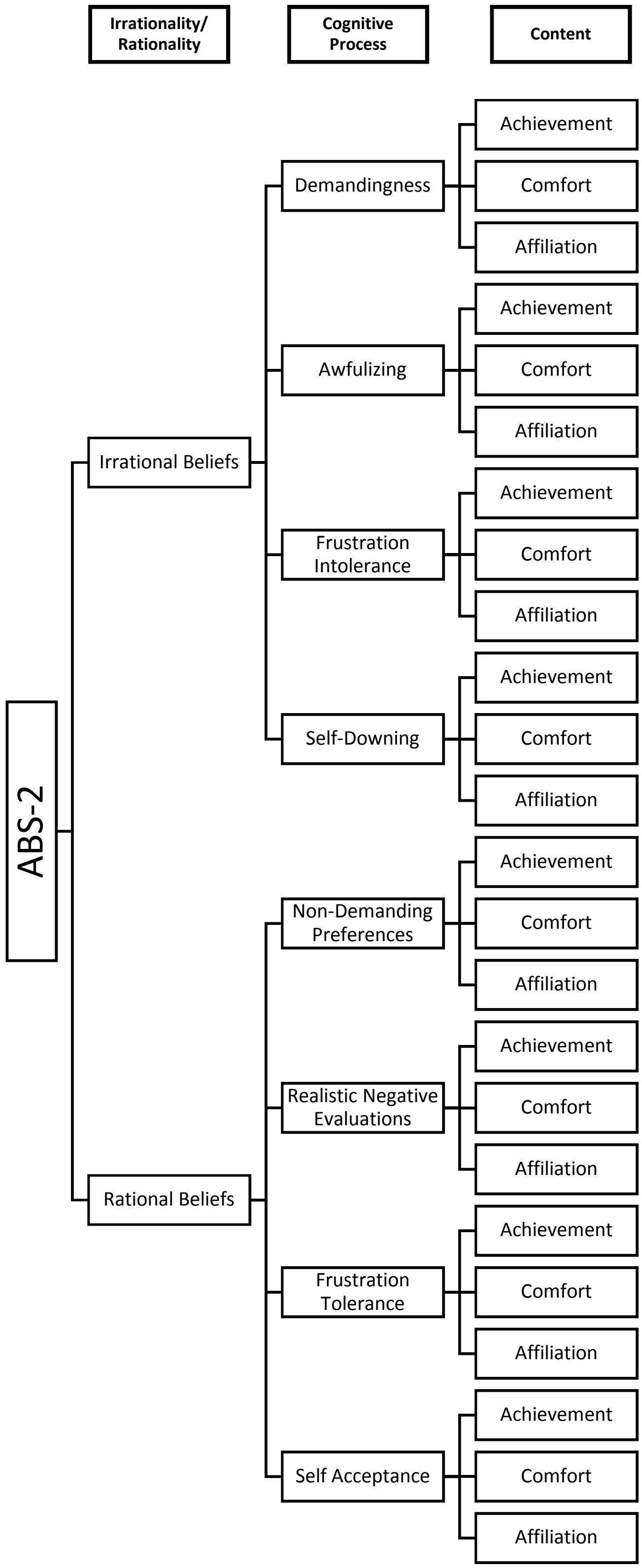
<u>Table 6: Results of the CFA for the DRLG using lavaan and DWLS estimation</u>

Results of the CFA for the **DRLG.** All models tested using lavaan with Diagonally Weighted Least Squares estimation.
Reporting Chi-Square Test of Model Fit, Degrees of Freedom, Ratio of χ^2 to degrees of freedom (χ^2 /*df*), Expected Cross-Validation Index (ECVI), Root Mean Square Error of Approximation (RMSEA), Standardized Root Mean Square Residual (SRMR), Bentler-Bonett Normed Fit Index (NFI), Comparative Fit Index (CFI), Tucker-Lewis Fit Index (TLI), Bollen's Relative Fit Index (RFI), and Bollen's Incremental Fit Index (IFI).

Models	χ^2	*df*	*# of parameters*	χ^2/df	**ECVI**	**RMSEA**	**SRMR**	**NFI**	**CFI**	**TLI**	**RFI**	**IFI**
Model 1	1700.53	252	48	6.75	0.86	0.05	0.06	0.97	0.97	0.97	0.97	0.97
Model 2	1213.24	251	49	4.83	0.63	0.04	0.05	0.98	0.98	0.98	0.98	0.98
Model 3	1470.66	249	51	5.91	0.75	.05	0.05	0.97	0.98	0.98	0.97	0.98
Model 4	1504.50	246	54	6.12	0.77	.05	0.05	0.97	0.98	0.97	0.97	0.98
Model 5	830.69	224	76	3.71	0.47	0.04	0.04	0.99	0.99	0.99	0.98	0.99
Bifactor Models												
Model 2G	693.92	225	75	3.08	0.40	.03	.04	0.99	0.99	0.99	0.98	0.99
Model 3G	669.66	222	78	3.02	0.39	.03	.04	0.99	0.99	0.99	0.99	0.99
Model 4G	767.13	218	82	3.52	0.44	.04	.04	0.99	0.99	0.99	0.98	0.99
Model 5G	486.99	192	108	2.54	0.34	.03	.03	0.99	0.99	0.99	0.99	1.0
Higher-Order Models												
Model 6	1494.93	244	56	6.13	0.77	0.05	0.05	0.97	0.98	0.97	0.97	0.98
Model 7	1110.66	243	57	4.57	0.59	0.04	0.05	0.98	0.98	0.98	0.98	0.98

Note: X^2= Chi-Square Test of Model Fit; ECVI= Expected Cross-Validation Index; RMSEA = Root Mean Square Error of Approximation; CFI = Cumulative Fit Index; TLI = Tucker- Lewis Index; SRMR = Standardized Root Mean Square Residual; Bentler-Bonett Normed Fit Index (NFI); Bollen's Relative Fit Index (RFI); Bollen's Incremental Fit Index (IFI)
N = 1593.

Figure 1: The theoretical structure of the Attitudes and Beliefs Scale (ABS-2)



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